CERAMIC BRUSH SEALS DEVELOPMENT

Harold Howe
Technetics Corporation
DeLand, Florida

CERAMIC BRUSH SEALS

METALLIC BRUSH SEALS

A. BENEFITS OVER CURRENT SEALS

1. HIGHER EFFICIENCY
2. ABLE TO WITHSTAND SHAFT EXCURSIONS
3. ABLE TO TAKE UP BUILD TOLERANCES
4. REDUCE SECONDARY FLOW LOSSES

B. LIMITATIONS

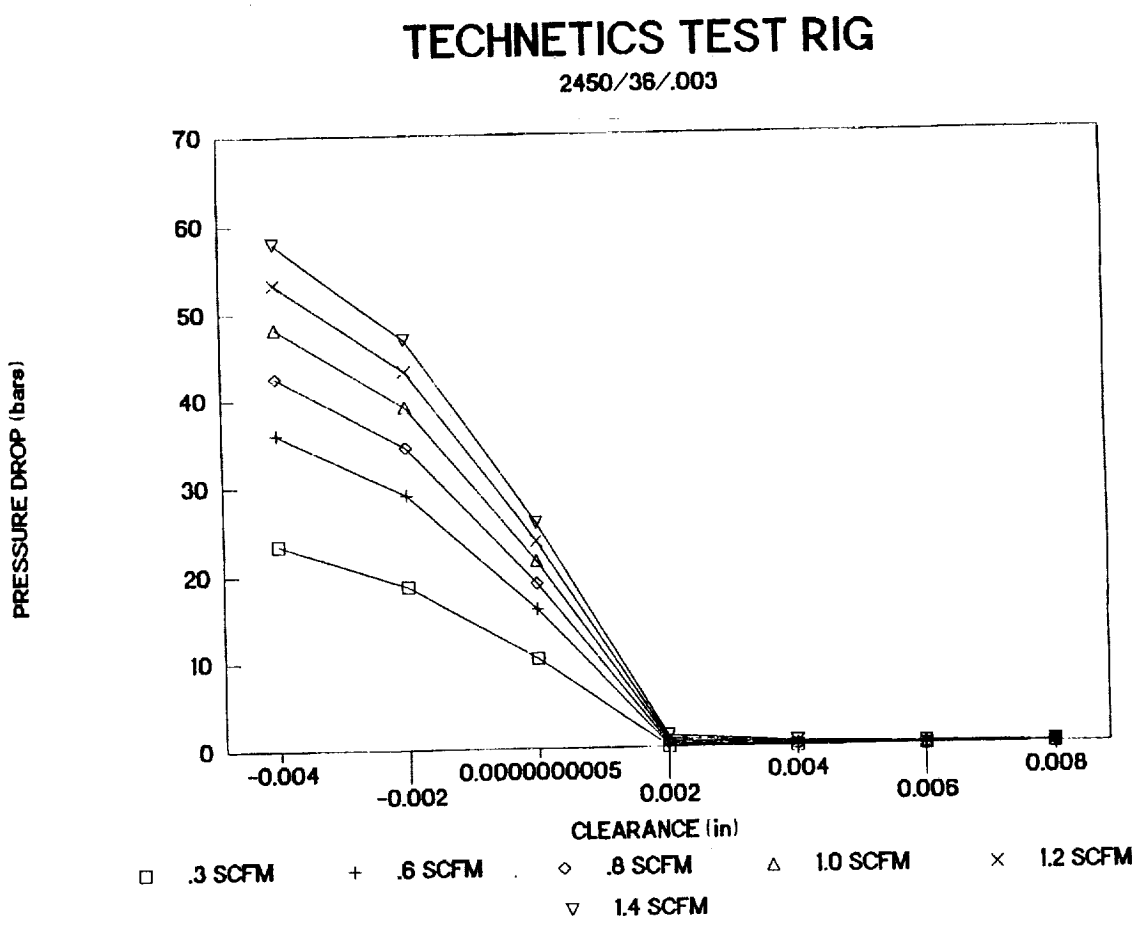
1. TEMPERATURE
2. LIFE/WEAR
3. OXIDATION

CERAMIC

A. HIGHER TEMPERATURE

B. LOWER WEAR

C. INTERFERENCE FIT BENEFIT



R & D

PURPOSE:

A. INVESTIGATE AND SHOW FEASIBILITY

B. BUILD AND INITIAL TEST OF CERAMIC BRUSH SEAL

TECHNICAL OBJECTIVES:

A. IDENTIFY MATERIALS

B. DEMONSTRATE MANUFACTURABILITY

C. TEST SEAL INTEGRITY

MATERIALS:

INDUSTRY STANDARD MATERIALS

CERAMIC FIBER

A. NEEDS

1. SIZE (.002"-.006")

2. FLEXIBLE

3. QUALITY

4. PRICE

B. AVAILABLE

1. ALUMINUM OXIDE

2. SILICON CARBIDE

3. TITANIUM DIBORIDE

4. QUARTZ

AVAILABLE CERAMIC BRISTLE MATERIALS

	Al_2O_3 Single Crystal	SiC CVD Filament	SiO_2 Fiber Optics
Size	.005	.0056/.0031	.004
Modulus (Msi)	60	58	10
Tensile (ksi)	--	500	--
Hardness (mohs)	9	2040-4487 $\frac{KG}{MM^2}$ Vickers	7-8
Bend Radius (in)	5/16	13/64 / 7/64	1
Operating Temperature (°F)	3632	Below 1800	2000

HAYNES 25

COBALT ALLOY

Modulus (Msi)	25.9 @ 1300°F
Tensile (ksi)	145-165
Operating Tempeature (°F)	1200-1400°F

MANUFACTURING

A. ALL CERAMIC

1. BRISTLES CAST IN PLACE
2. BRISTLES PRESSED IN PLACE
3. POST FIRING BRISTLE PLACEMENT

B. BRAZED ASSEMBLY

1. METAL BACKING/CERAMIC FIBER
2. PLATING PROCESS
3. DIRECT BRAZE PROCESS

BRAZED ASSEMBLY DEVELOPMENT

A. BRAZE ALLOYS

1. DUCTILE
2. HIGH TEMPERATURE
3. OXIDATION RESISTANT

B. BRAZE METHOD (WETTING OF CERAMIC)

1. MOLY-MANGANESE
2. ACTIVE METALS
   i.e., Ti, Zr, V, etc. (ABA)
3. ACTIVE METAL HYDRIDES
   i.e., TiH_2, ZrH_2, etc.

CONTROLLING BRAZE FLOW

A. EXCESSIVE WICKING

1. ABA ALLOYS (i.e., TiCuSil)
2. ACTIVE METAL BRAZING

B. LIMIT FLOW USING BRAZE BARRIERS (STOP-OFF)

C. ACTIVE METAL HYDRIDE PROCESS

1. ONE STEP
2. EASY APPLICATION
3. ALLOWS FOR BATCH PROCESSING
4. BRAZE ONLY WHERE ACTIVE METAL IS DEPOSITED

BRAZE ALLOYS

NAME	COMPOSITION	LIQUIDUS (°F)	SOLIDUS (°F)
CUSIL	AG - 72 CU - 28	1436	1436
TICUSIL	TI - 4.5 CU - 26.7 AG - 68.8	1562	1526
50% GOLD 50% COPPER	AU - 50 CU - 50	1778	1751
PALMANSIL 5	AG - 75 PD - 20 MN - 5	1962	1846
NIORO (AMS-4787; BAU-4)	AU - 82 NI - 18	1742	1742
PALNIRO 1 (AMS-4784)	AU - 50 PD - 25 NI - 25	2050	2016
PALNIRO 7 (AMS-4786)	AU - 70 PD - 8 NI - 22	1899	1841

FIBER SELECTION

1. QUARTZ (SiO_2)
2. ALUMINUM OXIDE (Al_2O_3)
3. SILICON CARBIDE (SiC)

CONSIDERATIONS

1. AVAILABILITY (Size/Price)
2. BRAZE WETTING
3. USE TEMPERATURE
4. INTEGRITY OF ASSEMBLY

BRAZE RESULTS

1. ALUMINUM OXIDE
2. QUARTZ
3. SILICON CARBIDE/Ni
4. SILICON CARBIDE/CuSil
5. SILICON CARBIDE/Au-Cu
6. SILICON CARBIDE/PALMANSIL

CURRENT CONFIGURATION

1. SiC/CuSil to 1200°F
2. SiC/Au-Cu to 1600°F

PRELIMINARY TEST RESULTS

1. LOW WEAR
2. SAME PERFORMANCE AS METALLICS
3. HIGH FRICTIONAL HEATING

CURRENT WORK

1. HIGHER TEMPERATURE FIBERS
2. HIGHER TEMPERATURE BRAZE ALLOYS
3. OTHER ACTIVE METAL HYDRIDES
4. IMPROVING PROCESS
5. TESTING

FUTURE WORK

1. ROTOR COATING
2. FURTHER TESTING
3. ALL-CERAMIC BRUSH SEAL

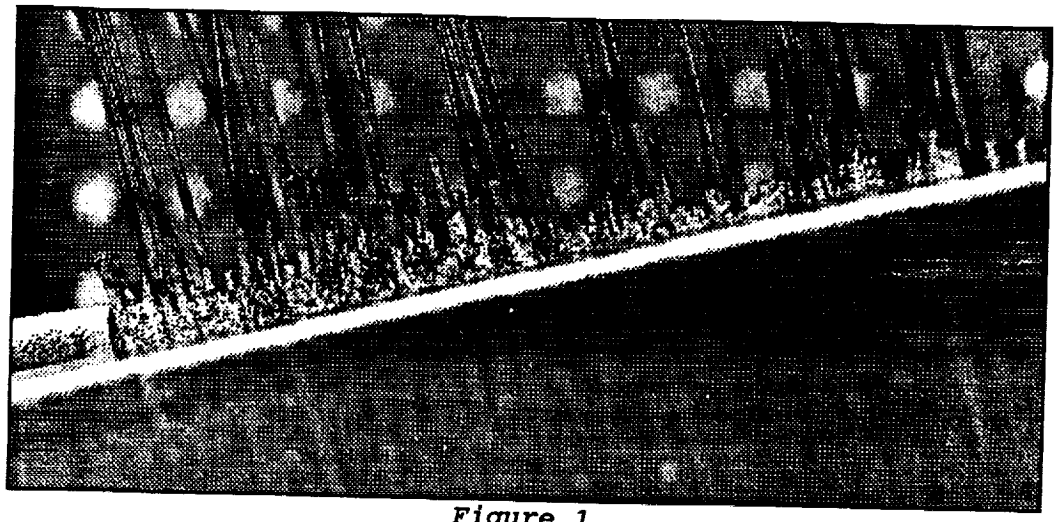


Figure 1
Sic/Palniro 7 Braze Sample

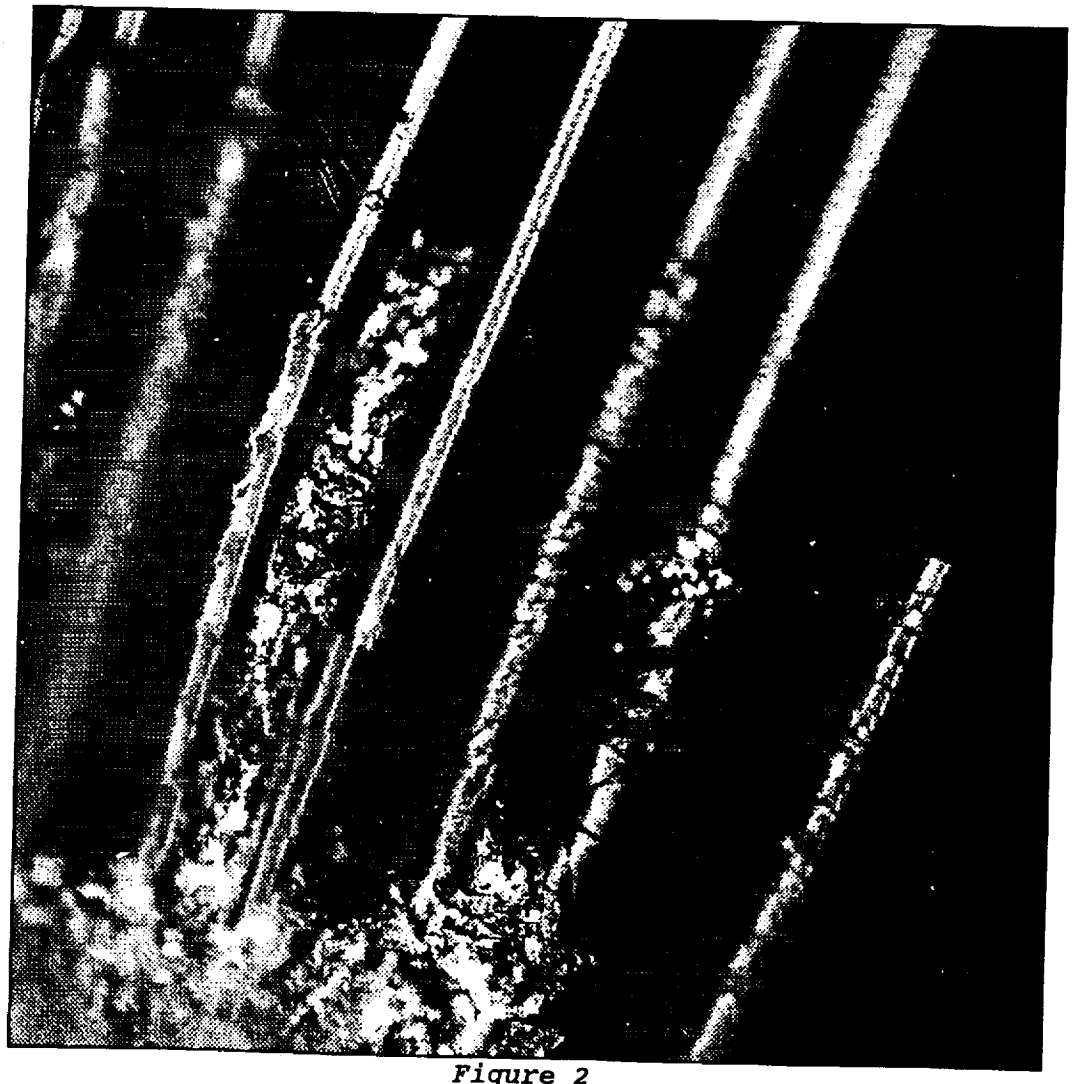


Figure 2
Nickel Attack on SiC Fiber

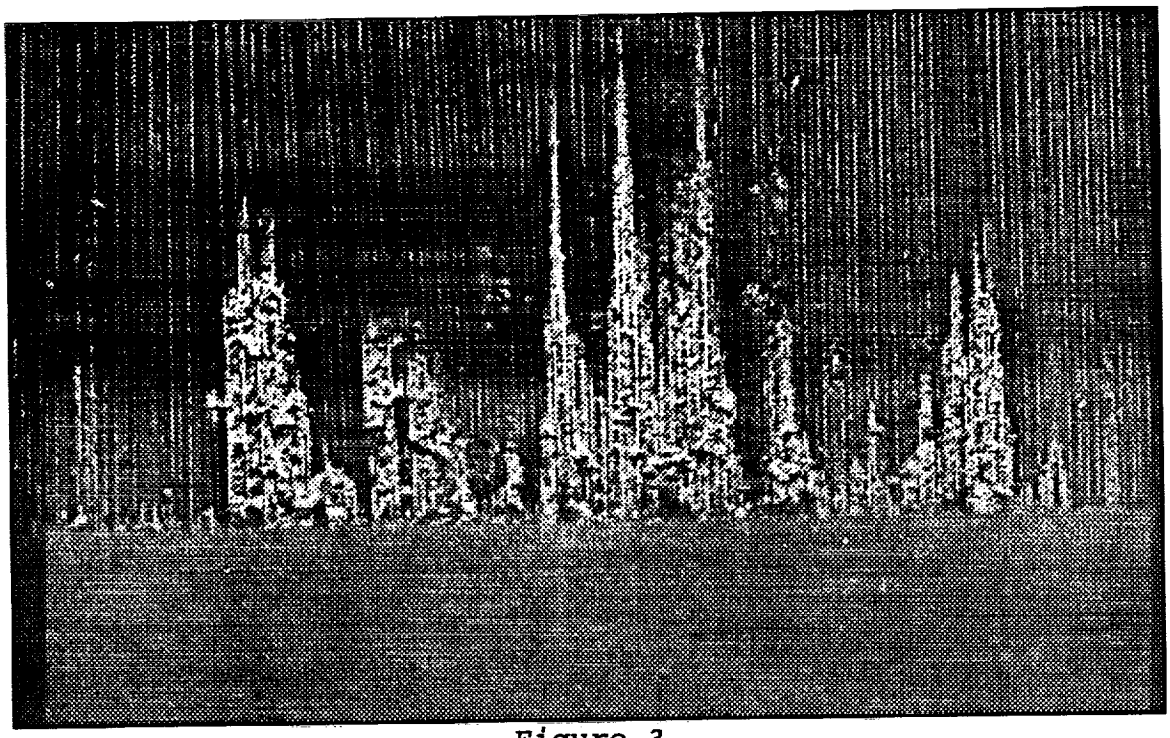


Figure 3
Cusil/Active Metal Wicking

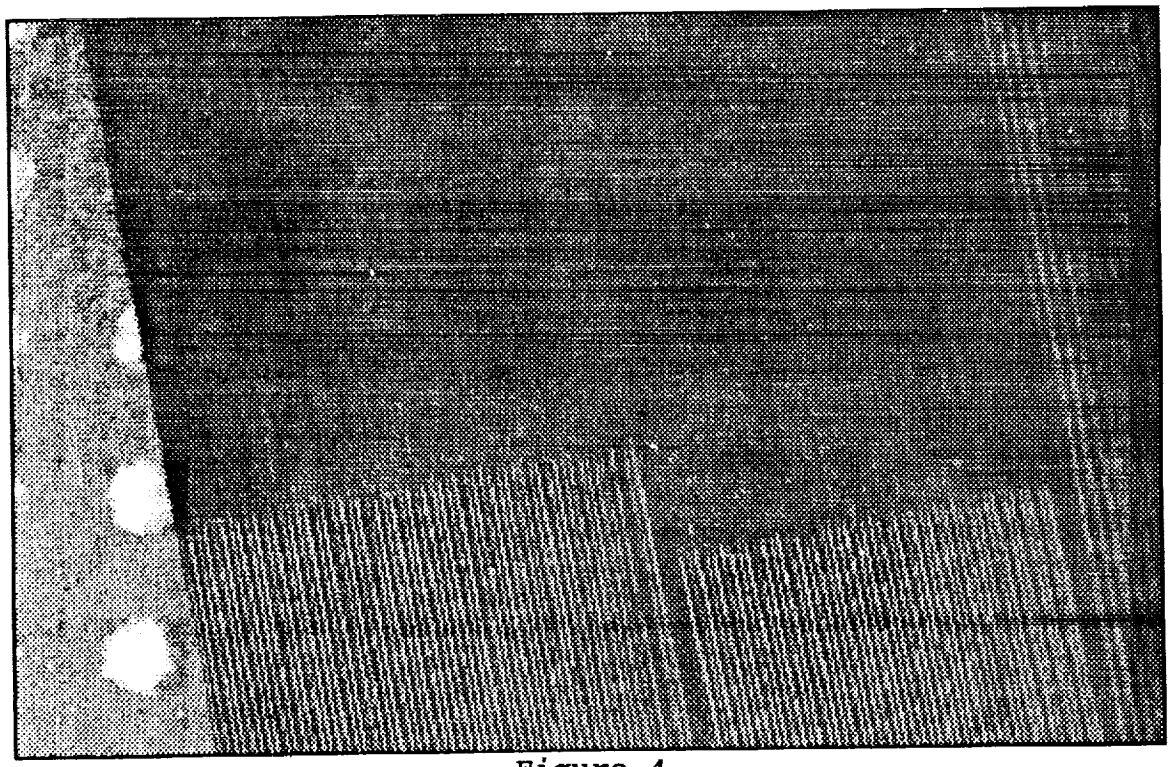


Figure 4
Active Metal Hydride on SiC Fiber

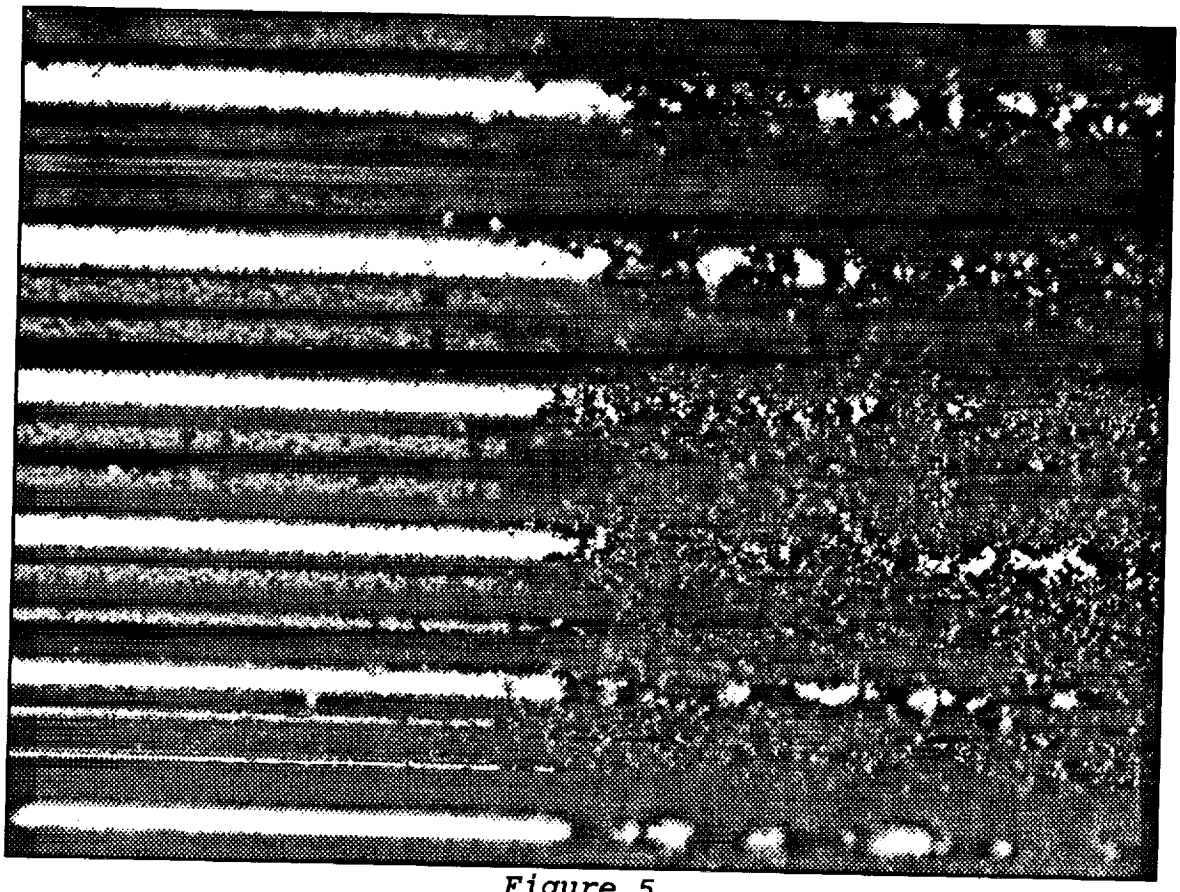


Figure 5
Active Metal Hydide Deposited on SiC Fiber

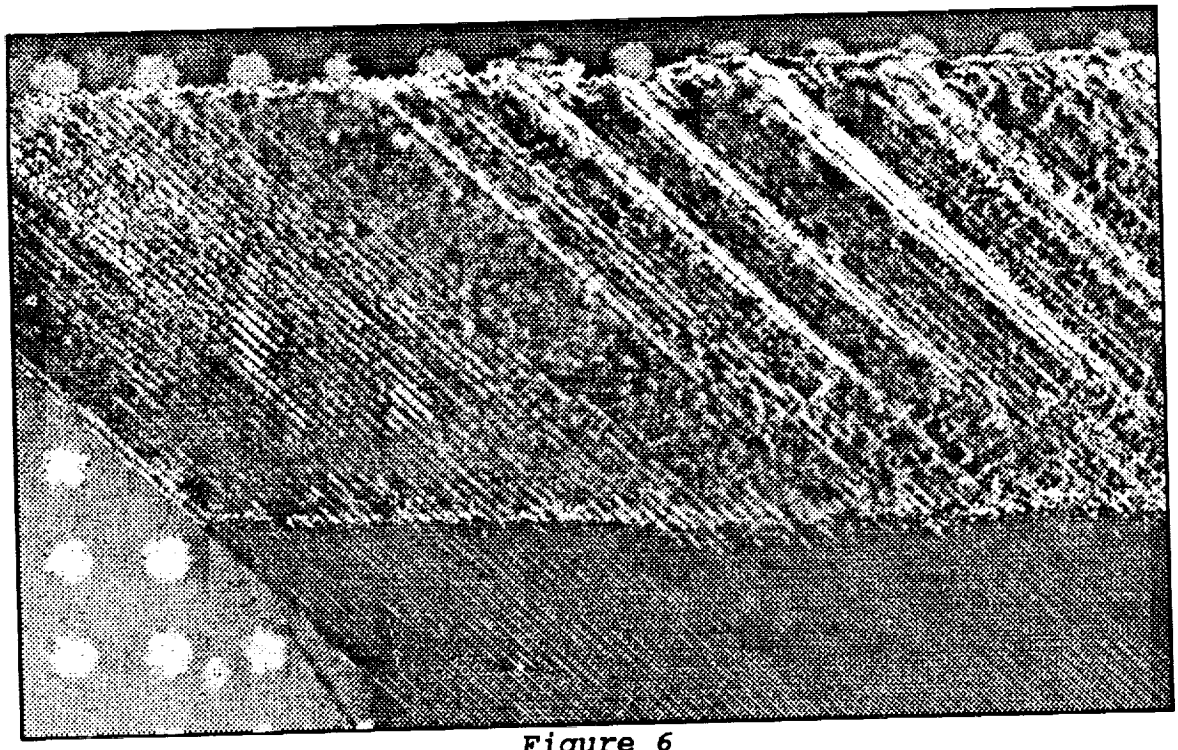


Figure 6
SiC Fiber Braze Sample
Cusil/Active Metal Hydride

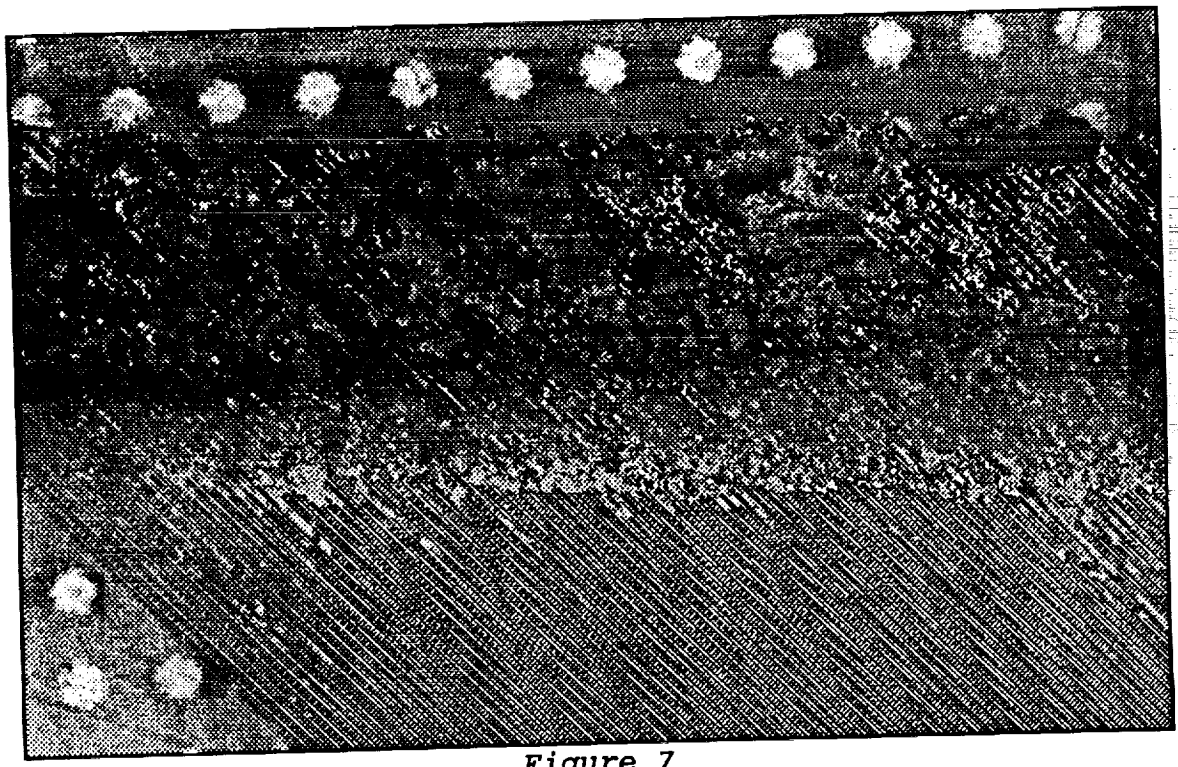


Figure 7
Improper Active Metal Hydride Application Result

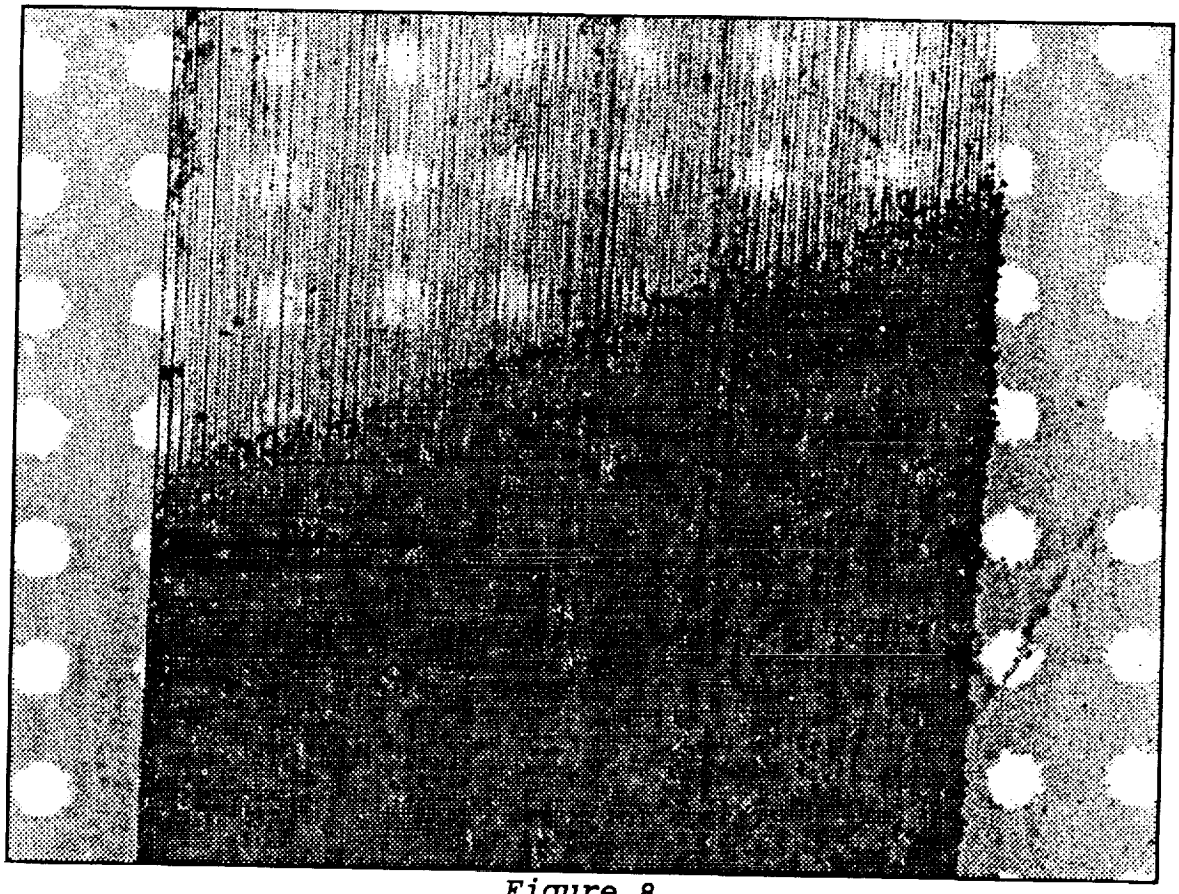


Figure 8
Aluminum Oxide/50% Gold 50% Copper Braze Sample

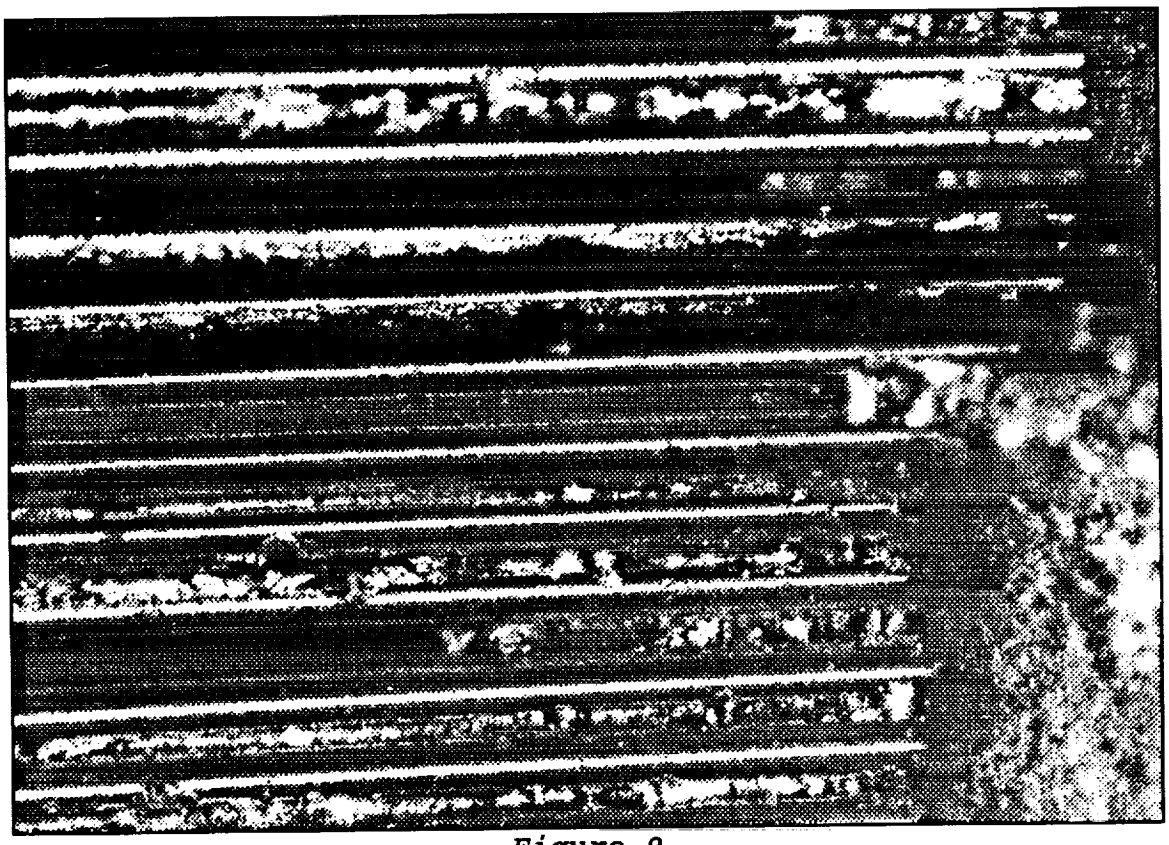


Figure 9
SiC Fiber/Active Metal Hydride
Active Metal Flow

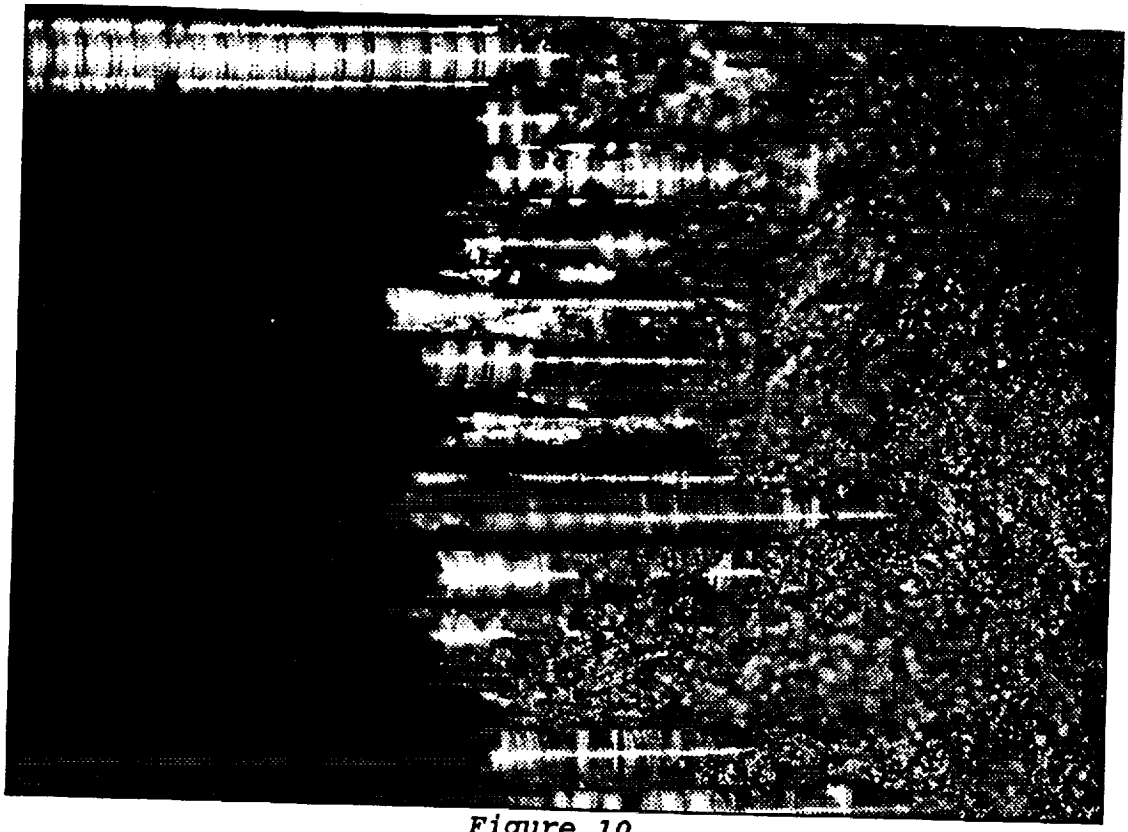


Figure 10
Aluminum Oxide/50% Gold 50% Copper
Dark Field

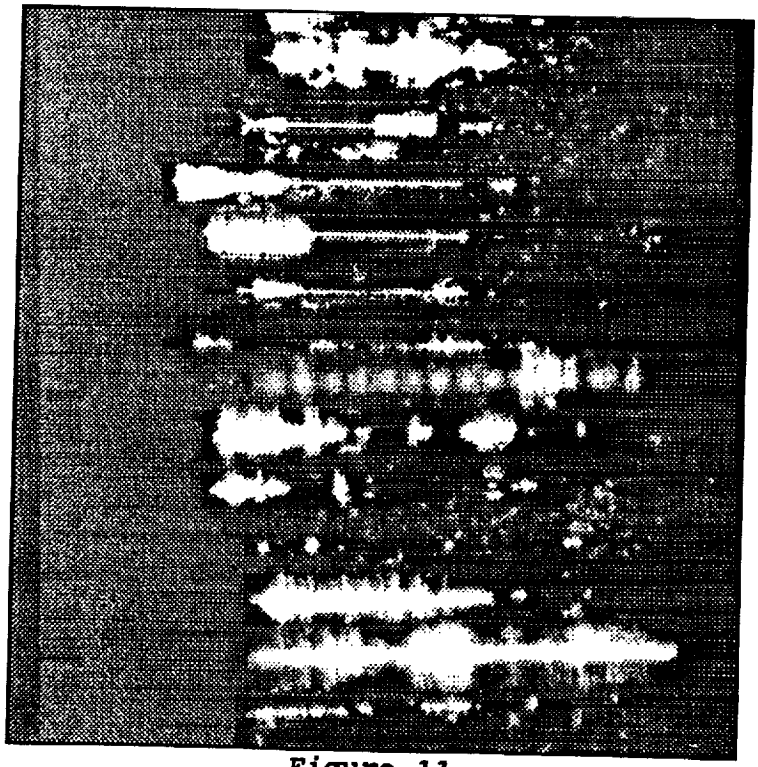


Figure 11
Aluminum Oxide/50% Gold 50% Copper
Light Field

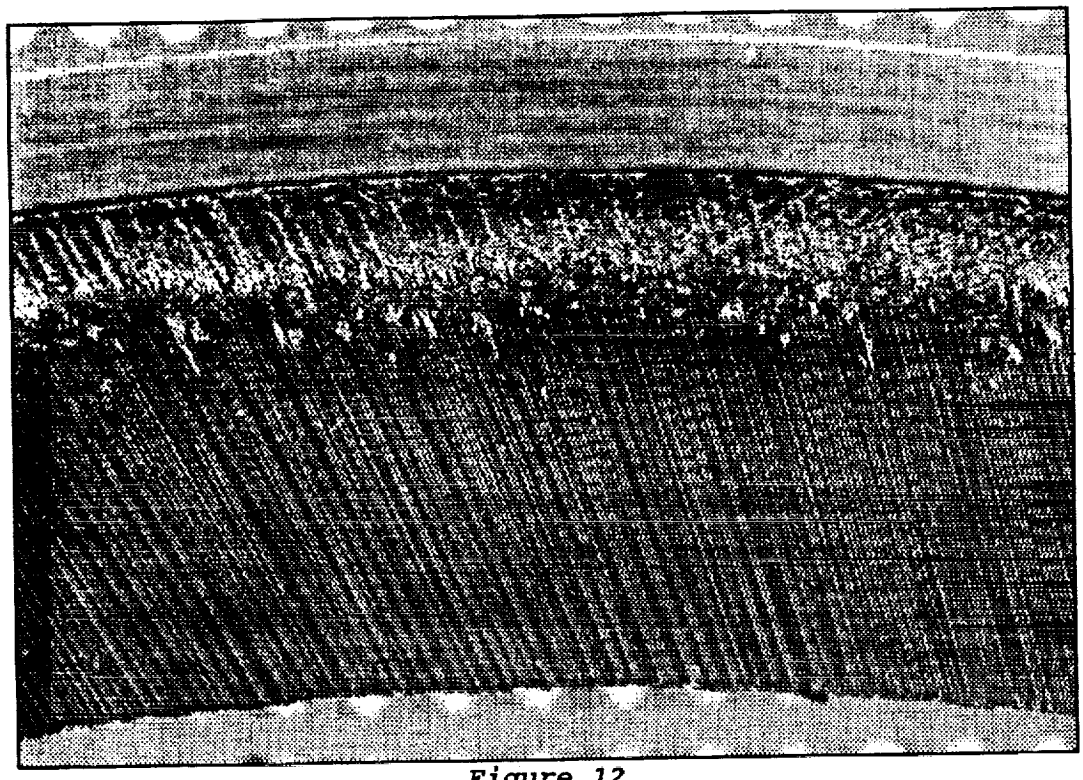


Figure 12
SiC/Cusil/Titanium Hydride - Brush Seal

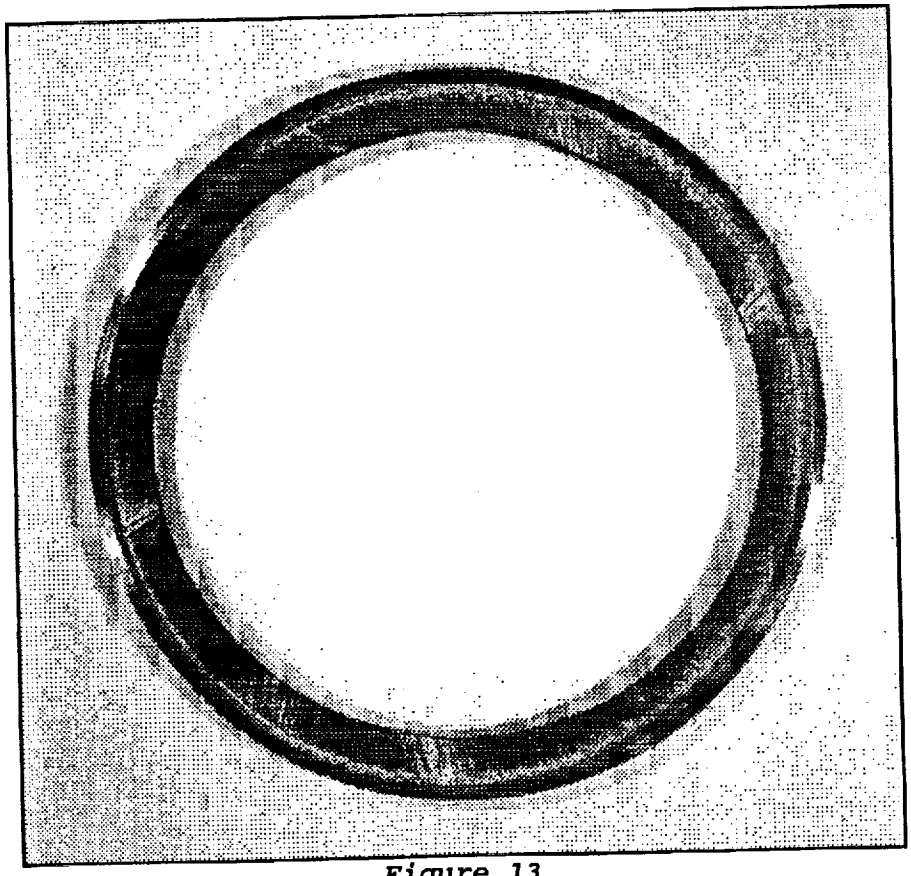


Figure 13
Brazed SiC Fiber/Metal Backing - Brush Seal

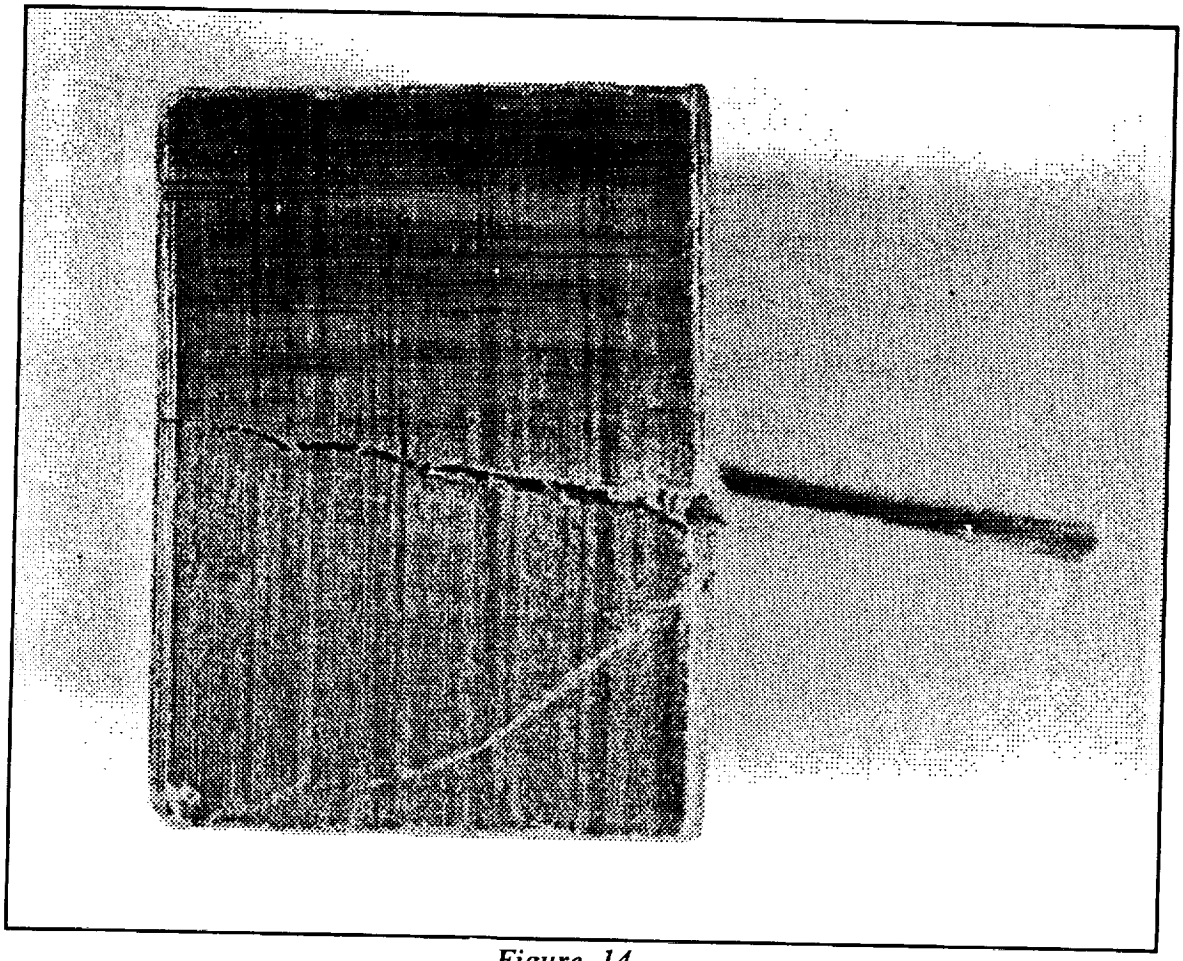


Figure 14
Cracking in Ceramic
Ceramic Powder Pressed Around Fiber

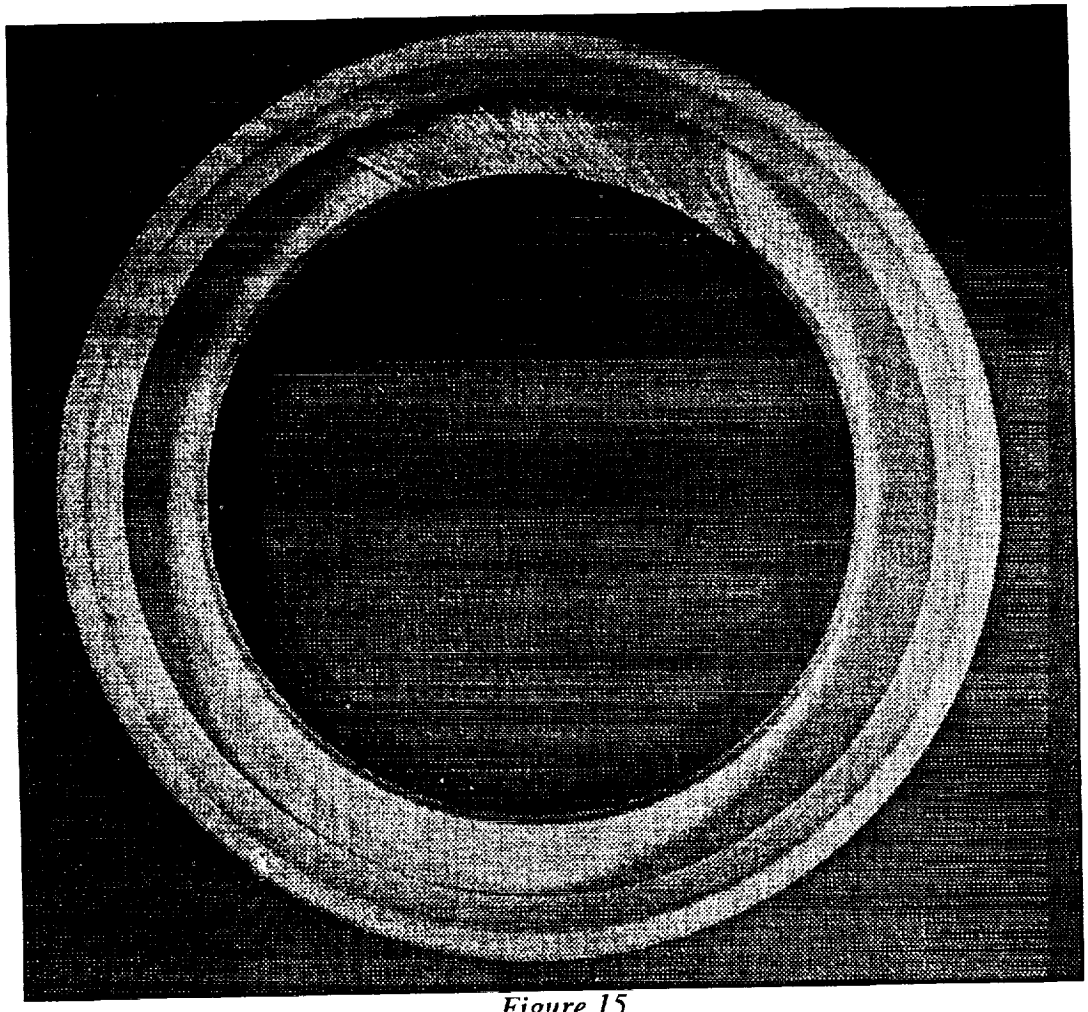


Figure 15
All-Ceramic Brush Seal Concept
Fiber Placed After Firing

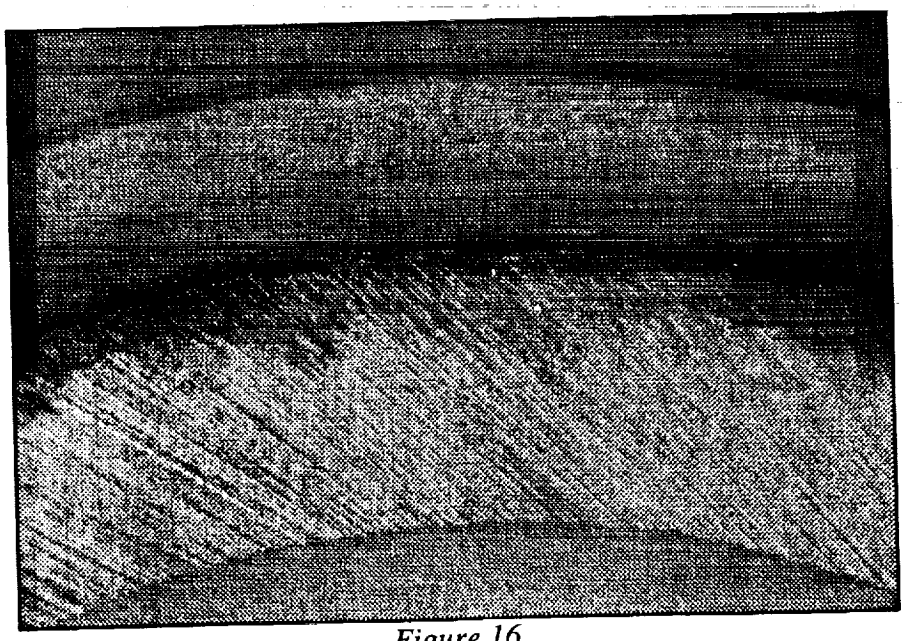


Figure 16
Ceramic Ring with Aluminum Oxide Fiber